

University of Groningen

## Psychophysical capacity in non-specific chronic low back pain

Hodselmans, Audy Paul

**IMPORTANT NOTE:** You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

*Document Version*

Publisher's PDF, also known as Version of record

*Publication date:*

2009

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Hodselmans, A. P. (2009). *Psychophysical capacity in non-specific chronic low back pain*. [Thesis fully internal (DIV), University of Groningen]. [s.n.].

### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.



## Chapter 4

# *Test-retest reliability of psychophysical lift capacity, in patients with non-specific chronic low back pain and healthy subjects*

Hodselmans AP  
Dijkstra PU  
Geertzen JHB  
Schans van der CP

Published in:  
Journal of Rehabilitation Medicine 2007 Mar; 39(2):133-137  
Reprinted with the kind permission of JRM

### **Abstract**

#### *Objective:*

Psychophysical lift capacity tests are lifting tests in which the performance, expressed in Newton, is divided by the perceived exertion, expressed on a Borg scale. The aim of this study was to analyse test-retest reliability of psychophysical lift capacity tests.

*Subjects:* patients with non-specific chronic low back pain (CLBP) (n = 20) and healthy subjects (n = 20)

#### *Methods:*

Psychophysical lift capacity tests were assessed during a cognitive somatic back school intake at the Centre for Rehabilitation of the University Medical Centre Groningen. Patients of the waiting list and healthy subjects were assessed twice, with a 2-week interval between assessments.

Intra Class Correlation (ICC) was calculated as a measure of reliability. An  $ICC \geq 0.75$  was considered as an acceptable reliability. Limits of agreement as a measure for natural variation were calculated.

#### *Results:*

The psychophysical static and dynamic lift capacity tests showed a good reliability ( $ICC \geq 0.75$ ). The limits of agreement are substantial, indicating a considerable natural variation between test-sessions for all psychophysical lift tests.

#### *Conclusion:*

The psychophysical static lift capacity and psychophysical dynamic lifting capacity are reliable instruments for patients with non-specific chronic low back pain and healthy subjects. However, a substantial amount of natural variation should be taken into account between 2 test sessions when interpreting the test results clinically.

## Introduction

Traditional clinical assessments of patients with non-specific chronic low back pain (CLBP) are most commonly based on tests of physical disability (e.g., range of motion and strength) [1-4] and tests of physical capacity that rely on a functional capacity evaluation (FCE). These tests of physical capacity are entrenched in current practice, but reliability and validity are generally weak [1,5-7]. For instance, isokinetic devices are commonly used to quantify trunk strength and motion. However, reliability of patient performance on the equipment is low and these isokinetic test batteries require extensive equipment [1]. Furthermore, the constrained manner of testing is functionally unrealistic, implying that correlations between the test results and function (i.e. validity) may be questionable [1,8].

The Isernhagen FCE has its limitations also in clinical evaluation because of ceiling- and criterion effects in some of the tests [9]. In these tests, many patients are not limited in the performance and meet the maximal test criterion [9]. Thus improvements in performance as a result of an intervention program can not be determined with these tests of the Isernhagen FCE due to these criterion effects.

Perceived disability is frequently inferred from physical performance measures but the outcomes may have little relation to actual functioning [1,10]. Changes in range of motion, muscle strength and physical fitness after a physical exercise program in a rehabilitation centre are not related to changes in the perceived disability measured with the Roland Morris Disability Questionnaire (RMDQ) [1,11].

Patient's perceptions of the level of disability as measured by for example the RMDQ may be subject to a perceptual or belief mismatch [12,13]. There may be differences between how patients actually function and how they perceive their functioning, and there may be differences in what patients report and in what practitioners observe and conclude, especially when patients are receiving injury compensation [1,14]. This mismatch may negatively influence the willingness and sense of safety while accomplishing specific physical tasks which cause loading of the lower back [1,15]. Therefore psychophysical capacity approach and outcome calculated as the acceptable maximal effort (AME) of the patient divided by perceived effort of the performance, may help to address the sense of safety of the patient [16,17]. The sense of safety exists because the patient determines which termination is acceptable. The perceived effort is weighted in the result of the psychophysical capacity.

It was found that the most important variable for successfully treating of CLBP is the reduction of patients' perceived disability, and that an appropriate perception of physical improvement contributes to the reduction in perceived disability [18]. Following a cognitive somatic rehabilitation approach for non-specific CLBP patients the change of

the psychophysical trunk lift capacity was significantly related to the change of the RMDQ ( $r = 0.74$ ) [16].

Until now no information is available concerning the test-retest reliability of psychophysical capacity tests [16]. The purpose of this study was to assess the test-retest reliability of the psychophysical capacity test.

### **Material and Methods**

#### *Participants*

The test-retest reliability and the natural variation of psychophysical tests were evaluated in 20 outpatients (12 women) with non-specific CLBP and in 20 healthy, pain-free controls (10 women). The patients were recruited from the Centre for Rehabilitation of the University Medical Centre Groningen. The mean age of the CLBP group was 33.8 years (SD=8.6), mean height was 1.76 m (SD=0.1) and mean weight was 73.9 kg (SD =15.1). The healthy subjects comprised students from the Institute for Human Movement Sciences of the University of Groningen. The mean age of the healthy subjects was 22.0 years (SD=1.6), mean height was 1.79 m (SD=0.1) and mean weight was 72.5 kg (SD=8.5).

#### *Procedure*

Admittance assessment was performed by a rehabilitation physician at the University Medical Centre Groningen before patients entered into the study. Inclusion criteria for the waiting list of the cognitive somatic back school rehabilitation treatment program are: (1) Non-specific CLBP, lasting for more than three months and without demonstrable specific origin; (2) the patient is satisfied with the diagnostic process and outcome, and is motivated for the rehabilitation treatment [16]. Exclusion criteria were: (1) small amount of suffering due to low back pain; (2) conflicts with employer or insurance company; (3) the patient is dissatisfied with the diagnostic process or outcome of it or is not motivated for the treatment program (secondary illness profits) [16]. Exclusion criteria for patients and controls were any medical condition that would interfere with psychophysical performance tests, major surgery within the last year, current infectious disease, cancer and neuralgic or cardiovascular disease. Additionally, subjects in the healthy group were excluded if they had a history of LBP within the previous 6 months that had lasted more than one week, required medical attention, or resulted in absence from work or school. All participants signed an informed consent form. The first author was the physical therapist who assessed the psychophysical capacity of the patients and the healthy subjects [16]. Patients of the waiting list and healthy subjects were assessed twice; the second test was done after a 2-week interval. Time of day, day of week and place of assessment

## Test-retest reliability of psychophysical lift capacity, in patients with non-specific chronic low back pain and healthy subjects

were held constant for the test-sessions. Patients on the waiting list were assessed twice before starting the cognitive somatic back school rehabilitation program.

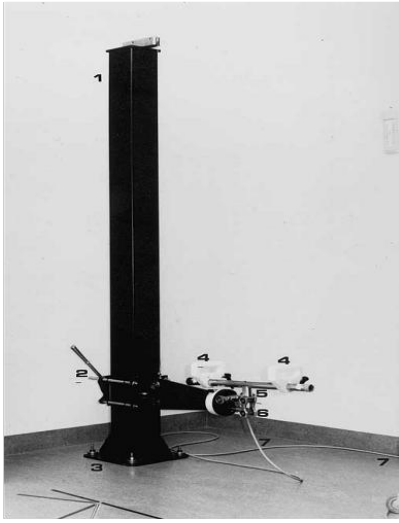
### *Measurements*

Aerobic capacity was estimated by means of an LBM-based Åstrand submaximal test on a cycle ergometer (Excalibur Sport, Lode BV, Groningen, The Netherlands) before the psychophysical capacity tests were performed [16]. The method for measuring lifting abilities is based upon a psychophysical model referred to as AME [17].

### *Psychophysical static lift capacity test*

The psychophysical static lift capacity test was performed by pulling up a horizontal bar connected to a height-adjustable pillar (Fig 1) [16]. The vertical force was measured with a force transducer (EBN 8500-1250, Depx type brosia; GmbH & Co, Tettnang, Germany; range 0 to 2500 N; linearity 0.02%) and an amplifier (Elan-Schaltelemente MBP 6218; Kurt Maecker GmbH, Neuss 1, Germany; range , 500  $\mu\text{m/m}$  to 5000  $\mu\text{m/m}$ ) and was registered on a plotter (PM 8043 Eindhoven, The Netherlands; range, 2 mV/cm to 1V/cm). Three static lift tests described by Chaffin et al were performed: the arm lift, leg lift and trunk lift [19]. The position of the subject during the arm lift was; standing straight up with the elbow bent at 90 degrees and close to the body. The equipment handles were at elbow height. During the arm lift and trunk lift the horizontal distance was 375 mm. The horizontal distance for the leg lift was 0 mm. The vertical distance during the leg lift and trunk lift was 500 mm.

In case of the psychophysical lifting capacity test the patient is in control and determines which load is acceptable. The psychophysical test performance was stopped when the patient believes the AME was reached. The patient was instructed to stop the performance when the AME was reached [17]. To measure patients perceived exertion the Borg score (range 0.5 – 10) was assessed directly after reaching the AME of the static lift capacity tests [20,21,22]. After the test, the subject pointed the perceived effort on a table where the explanation of the number was described. The Borg score is modified by changing the 0 score in 0.5 which corresponds to not at all, 1=very light, 2=light, 3=moderate, 4=slightly heavy, 5=heavy, 6= less than 7, 7= very heavy, 8= less than 9, 9= less than 10, 10= very terrible heavy (almost maximum). The psychophysical static lift capacity was calculated as the ratio of physical capacity and the Borg score, expressed in Newton/Borg (N/B) [16].



*Fig 1. Static lifting force measurement set-up:*

1. *pillar*
2. *height adjuster*
3. *floor*
4. *handle*
5. *joint*
6. *transducer*
7. *connection with amplifier/plotter.*

### *Psychophysical dynamic lifting capacity test*

To measure the psychophysical dynamic lifting capacity, the standardized Progressive Isoinertial Lifting Evaluation protocol (PILE), described by Mayer et al. was used [23,24].

For a period of 20 seconds the patient had to lift a box with weights, 4 times from the ground on to a table. Stepwise, after each session, during the 20 second rest, the weight of the box increased with 2.25 kg for women and 4.5 kg for men respectively. Heart rate was measured with a heart rate equipment (Sport tester PE-3000; Polar Electro, Kempele, Finland) [16]. The observer stopped the test when the patient had reached the heart rate safety limit ( $220 - \text{age} \times 85\%$ ) [16,25]. The patient was instructed to stop the test when the AME was reached [17]. Perceived exertion was assessed directly after reaching the AME, the cardiac safety limit (formula  $220 - \text{age} \times 85\%$ ) or the ceiling of the test of 402 N [26]. The psychophysical dynamic lifting capacity was calculated as the ratio of the physical capacity and Borg score, expressed in Newton/Borg (N/B) [16].

### **Data analysis**

Descriptive statistics were calculated for the scores of the 2 test-sessions. Test-retest reliability was determined by means of a paired t-test and intra class correlation coefficient (ICC, one way random model). To quantify variation over time, limits of agreement were calculated as  $\pm 2$  times  $\times$  SD difference [27,28]. In case of significant differences between the first and second test the limits of agreement were not calculated, because the test-retest reliability is unacceptable [28]. An  $\text{ICC} \geq 0.75$  was considered as an acceptable reliability [30,31].

## Test-retest reliability of psychophysical lift capacity, in patients with non-specific chronic low back pain and healthy subjects

No criteria for interpretation of the limits of agreement are available. However, smaller limits of agreement indicate more stability over time because it indicates that the natural variation is small [9]. Plots were made of the individual difference between sessions against the individual average of the two sessions, as recommended to analyse if the size of the difference is related to the mean performance [28]. Comparisons between groups were calculated by using the mean of the 2 test occasions for each group and thereafter a between group t-test analysis. Data analyses were performed using the Statistical Package of Social Sciences (SPSS 12.0).

### Results

Outcomes of psychophysical lift capacity tests did not differ significantly between the 2 sessions (table I). In patients, AME of physical strength only, in Newton's, was significantly lower in the second session than the first session. The standard deviations of all measurements are considerable. No funnel shape was present in the plots (Fig. 2) indicating that the difference between the two sessions is not related to the average tests on the 2 sessions. The other 3 figures are similar.

The ICC for the psychophysical lift capacity ranged from 0.82 to 0.93 in patients and from 0.75 to 0.94 in healthy subjects (table II). Limits of agreements ranged for the psychophysical static lift capacity tests in patients from  $\pm 26$  N/B to  $\pm 106$  N/B and in healthy subjects from  $\pm 42$  N/B to  $\pm 170$  N/B respectively. The psychophysical dynamic lifting (PILE) capacity had a limit of agreement in patients of  $\pm 14.2$  N/B and  $\pm 19.6$  N/B in healthy subjects. Psychophysical lift capacity tests (N/B) of healthy subjects showed significantly higher values than patients in leg lift ( $p=0.007$ ) trunk lift ( $p=0.002$ ) and PILE ( $p=0,000$ ) except for the psychophysical arm lift capacity tests ( $p=0.227$ ).



Table 1: Results of patients and healthy subjects in the first and second measurement session of the psychophysical capacity in Newton/Borg, the AME in Newton and the perceived exertion in Borg.

Variable	Patients n=20		Healthy n=20		$\Delta T(sd)$	$T1(sd)$	$T2(sd)$	$\Delta T(sd)$
	$I(sd)$		$I(sd)$	$T2(sd)$				
Leg lift Newton/Borg	119.1(76.3)		108.1(59.7)		11.1(53)	185.1(104.1)	183.1(90.1)	1.73(85)
Newton	468.1(226.0)		395.1(182.0)		73.3(120)*	566.1(117.1)	610.1(208.1)	-44.3(107)
Borg	4.4(1.5)		4.0(1.9)		0.4(0.9)	3.6(1.6)	3.8(1.4)	-0.2(1.3)
Trunk lift Newton/Borg	71.6(40.4)		65.1(29.7)		6.4(20)	117(54.8)	123(61.9)	-6.5(21)
Newton	301.2(128.0)		266.2(106.1)		34.6(72)*	401.1(112.0)	395.1(142.0)	5.2(74)
Borg	4.7(1.6)		4.4(1.3)		0.3(1.1)	3.7(1.0)	3.5(1.1)	0.2(0.7)
Arm lift Newton/Borg	58.8(32.1)		54.9(28.4)		3.8(13)	67.3(32.4)	71.5(41.5)	-4.2(26)
Newton	215.1(68.1)		195.1(80)		19.8(39)*	262.1(89.9)	252.1(94)	10.8(31)
Borg	4.2(1.4)		3.8(1.2)		0.4(0.9)	4.3(1.3)	4.0(1.3)	0.3(1.2)
PILE Newton/Borg	33.9(17.6)		33.6(18.9)		0.3(7.1)	65.2(27.4)	68.3(29.2)	-3.1(9.8)
Newton	170.1(81.6)		154.1(82.2)		15.7(30)*	287.1(96.5)	284.1(98.4)	2.2(22.9)
Borg	5.3(1.5)		4.9(1.4)		0.4(0.7)*	4.6(1.1)	4.3(0.7)	0.3(0.7)

\*: paired t test significant ( $p < 0.05$ )

$T1$ : mean value of the first assessment,  $T2$ : mean value of the second assessment

(sd): standard deviation,  $\Delta T$ : difference between  $T1$  and  $T2$

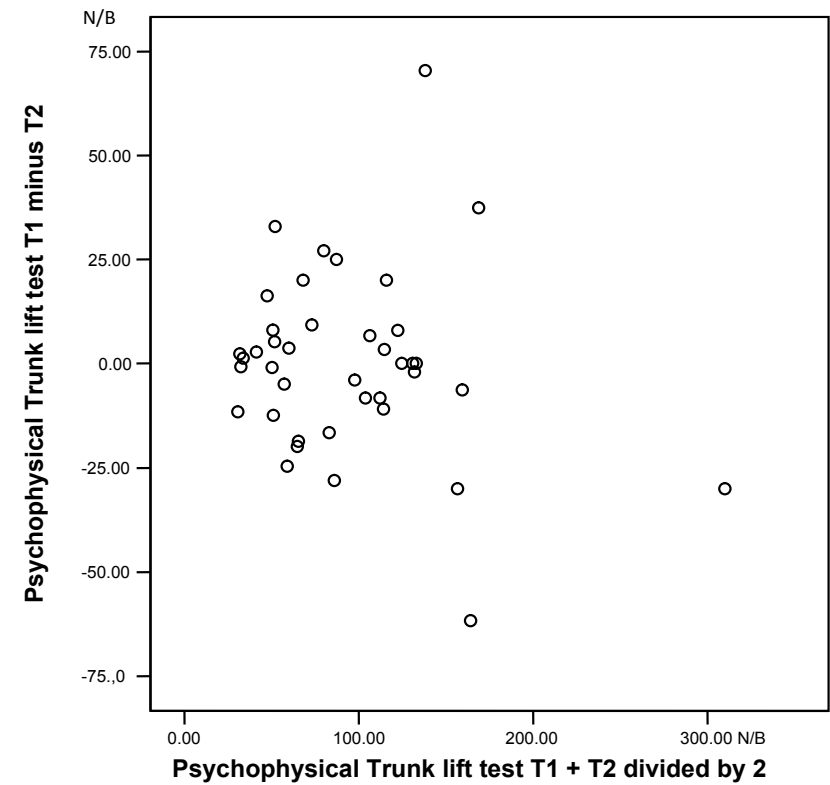
AME: Acceptable Maximal Effort PILE: Progressive Isoinertial Lifting Evaluation

Table II: Intra class correlation's (one way random model) for patients and healthy subjects of the psychophysical capacity tests N/B.

Psychophysical Capacity test in N/B	ICC	95% CI	Limits of Agreement (LOA) in N/B	Mean of two Measurements In N/B	LOA % of the Mean of two measurements
Patients N=20					
Leg lift	0.82	0.56 to 0.93	± 106.0	113.6	93
Trunk lift	0.83	0.62 to 0.93	± 40.0	68.3	59
Arm lift	0.89	0.79 to 0.96	± 26.0	56.9	46
PILE	0.93	0.83 to 0.97	± 14.2	33.8	42
Healthy N=20					
Leg lift	0.78	0.44 to 0.91	± 170.0	184.1	92
Trunk lift	0.93	0.82 to 0.97	± 42.0	120.0	35
Arm lift	0.75	0.48 to 0.89	± 52.0	69.4	75
PILE	0.94	0.85 to 0.97	± 19.6	66.8	29

ICC: Intra Class Correlation CI: confidence of Interval N/B: Newton/Borg  
PILE: Progressive Isoinertial Lifting Evaluation

Fig 2: Psychophysical trunk lift patients and healthy subjects  
Difference between Psychophysical trunk lift T1 and T2 scatter plotted against T1 + T2 divided by 2.



**Discussion**

A significant decrease was found in patients between session 1 and 2 of only strength (physical capacity) in Newton’s of the AME of static leg lift, trunk lift and arm lift and dynamic lifting (PILE). This significant decrease in patients with non-specific CLBP, confirms the inadequate reliability of traditional clinical assessments for these patients based on tests of physical strength alone (physical capacity) [1]. The SDs of all measurements are considerable. The cause can be the significant differences between men and women. However the values are normally distributed calculated with the 2-tailed kolomogorov - Smirnov test.

In all the measurements of the psychophysical capacity in patients and healthy subjects the ICC was > 0.75. This means that the psychophysical static lift capacity test and psychophysical dynamic lifting capacity test in patients and in healthy subjects are reliable.

## Test-retest reliability of psychophysical lift capacity, in patients with non-specific chronic low back pain and healthy subjects

However the 95% CI are large which suggest that, as in other studies ICC's lower than 0.75 may be found. On the other hand, the ICC expresses how well two observations are likely to classify a patient consistently relative to the other patients [32]. The ICC value provides no indication of the magnitude of the disagreement between two observations [33]. To determine the magnitude of disagreement on an individual level, the limits of agreement were calculated [29,30]. In other words, in an individual patient with non-specific CLBP the changes due to treatment should exceed limits of agreement before deciding that true changes have occurred. Despite the acceptable reliability (ICC) the limits of agreement were substantial of the psychophysical lift capacity tests in patients and healthy subjects. This means that the "noise" was relatively large. The limits of agreement of the psychophysical leg lift were large ( $\pm 106$  N/B) in patients. This means that true change can only be detected when an individual changes at least 93% in comparing to 113.6 N/B (table II). When the change is less than 93% after a treatment program, it may be due on natural variation. The limits of agreement of the psychophysical trunk lift capacity were  $\pm 40.0$  N/B in patients. This means that true change can only be detected when an individual changes at least 59% in comparing to 68.3 N/B (table II). When the psychophysical static trunk lift capacity in patients increases 59% they will almost reach the value of the healthy subjects. In a previous study we have shown that CLBP patients increased 87% in the psychophysical static trunk lift and 98% in the psychophysical static leg lift capacity test after a cognitive somatic rehabilitation approach [16]. For the psychophysical dynamic lifting capacity test this individual change has to be 42% in patients, which is also substantial. For the psychophysical dynamic lifting capacity test the difference between patients and healthy subjects was relatively larger. When the patients increase 42% the patients will not have reached the value of the healthy subjects. This may be because the psychophysical endurance of abdominal and back muscles is also important within the psychophysical dynamic lifting capacity test compared to the psychophysical static lift capacity test. This is supported by the result of the PILE that 17 of the healthy subjects and none of the patients ended the test due to the ceiling effect and in according of the results found in the study of Brox et al. [34].

Large limits are the result of a substantial within subject variation. This variation can be attributed to the testing procedure, or to other factors such as the patient or healthy subjects, differences in test behaviour like fear of pain, motivation or within subject random errors. However, perceived exertion or an appropriate perception of physical activities is important in the reduction of the perceived disability [18]. Table I shows that the Borg score is systematically higher in patients in both

measurements compared with the healthy subjects except for static arm lift capacity tests.

No significant difference between patients and healthy subjects was found for the first psychophysical static arm lift capacity ( $P=0.227$ ) which might be expected because patients did not experience arm pain and the lower back was held straight during lifting. The psychophysical dynamic lifting ( $P=0.000$ ) and static trunk lift ( $P=0.002$ ) and static leg lift capacity ( $P=0.007$ ) were significant lower in non-specific CLBP patients compared to healthy subjects which might be expected.

In conclusion, the present study shows that the psychophysical static lift capacity and psychophysical dynamic lifting capacity are reliable instruments for patients with non-specific CLBP and healthy subjects. However, a substantial amount of natural variation should be taken into account between two test sessions when interpreting the test results clinically.

## References

1. Simmonds MJ, Olson SL, Jones S, Hussein T, Lee CE, Novy D, et al. Psychometric characteristics and clinical usefulness of physical performance test in patients with low back pain. *Spine* 1994; 19:2759-2765.
2. Battie MC, Cherkin DC, Dunn R, et al. Managing Low Back Pain: Attitudes and treatment preferences of physical therapists. *Phys Ther* 1994; 74:219-226.
3. Novy DM, Simmonds MJ, Lee CE. Physical performance tasks: What are the underlying constructs. *Arch Phys Med Rehabil* 2002; 83:44-47.
4. Stratford PW, Binkley J, Solomon P. Defining the minimal level of change for the Roland Morris Questionnaire. *Phys Ther* 1996; 76:359-365.
5. Magee DM. Orthopedic Physical assessment. 2nd ed. Philadelphia: WB Saunders, 1992.
6. Potter NA, Rothstein Jm. Intertester reliability for selected clinical tests of the sacroiliac joint. *Phys Ther* 1985; 65:1671-1675.
7. Simmonds MJ, Kumar S, Health care ergonomics : part 2 Location of body structures by palpation. A reliability study. *Int J Ind Ergonomics* 1993; 11:145-151.
8. Newton M, Thow M, Somerville D, Henderson I, Waddell G. Trunk strength testing with iso-machines: part 2 Experimental evaluation of the cybex 2 back testing system in normal subjects and patients with chronic low back pain. *Spine* 1993; 18:812-824.
9. Brouwer S. Disability in chronic low back pain. Psychometric properties of ADL- and work-related instruments [dissertation]. Groningen: University Groningen; 2004.
10. Verbunt J. Disuse and physical deconditioning in chronic low back pain [dissertation]. Maastricht: University Maastricht; 2004.
11. Jillings-Rohaas JJ, Gorter MJ, Buurke JH, Baten CTM, Hermens HJ. Rugscholing in een revalidatiecentrum. *Ned Tijdschr voor Fysiother* 1997; 1:14-18.
12. Roland M, Morris R. A study of the natural history of low back pain. *Spine* 1983; 8:141-150.
13. Gommans IHB, Koes BW. Validiteit en responsiviteit Nederlandstalige Roland Disability Questionnaire. *Ned Tijdschr voor Fysiother* 1997; 2:28-33.
14. Fordyce WE, Lansky D, Calshyn DA, Shelton JL, Stolov WC, Rock DL. Pain measurement and pain behaviour. *Pain* 1984; 18:53-69.
15. Cunha IT, Simmonds MJ, Protas EJ, Jones S. Back pain, physical function and estimates of aerobic capacity: What are the relationships among methods and measures? *Am J Phys Med Rehabil* 2002; 81:913-920.

16. Hodselsmans AP, Jaegers SM, Göeken LNH. Short-term outcomes of a back school program for chronic low back pain. *Arch Phys Med Rehabil* 2001; 82:1099-1105.
17. Khalil TM, Goldberg ML, Asfour SS, Moty EA, Rosomoff RS, Rosomoff HL. Acceptable Maximum Effort (AME). A psychophysical measure of strength in back pain patients. *Spine* 1987; 12:372-376.
18. Hildebrandt J, Pfingsten M, Sauer P, Jansen J, Prediction of success from a multidisciplinary treatment program for chronic low back pain. *Spine* 1997; 22:990-1001.
19. Chaffin DB, Herrin GD and Moroe Keyserling W. Pre-employment strength testing; an updated position. *J Occ Med* 1978; 20:403-408.
20. Genaidy AM. Spinal compression tolerance limits for the design of manual material handling operations in the workplace. *Ergonomics* 1993; 36:415-434.
21. Borg G. Psychophysical bases of perceived exertion. *Med Sci Sports Exercise* 1982; 14: 377-381.
22. Troup JDG, Foreman T, Baxter C and Brown D. The perception of back pain and the role of psychophysical tests of lifting capacity. *Spine* 1987; 12: 645-657.
23. Mayer TG, Barnes D, Kishino ND, Nichols G, Gathcel RJ, Mayer H, et al. Progressive isoinertial lifting evaluation: 1. A standardized protocol and normative database. *Spine* 1988; 13: 993-997.
24. Mayer TG, Barnes D, Nichols G, Kishino ND, Coval K, Piel B, et al. Progressive isoinertial lifting evaluation: 2. A comparison with isokinetic lifting in a disabled chronic low-back pain industrial population. *Spine* 1988; 13: 998-1002.
25. Fox S. Physical activity and the prevention of coronary heart disease. *Ann Clin Res* 1971; 3:404-432.
26. Waters TR. Revised NIOSH equation for the design and evaluation of manual tasks. *Ergonomics* 1993; 7: 749-776.
27. Bland JM, Altman DG. Measurement error. (Clinical Research Ed) *BMJ* 1996; 313:744.
28. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; 8:307-310.
29. Altman DG, Bland JM. Measurement in medicine: The analysis of method comparison studies. *Statistician* 1983; 32:307-317.
30. Lee J, Koh D, Ong CN. Statistical evaluation of agreement between two methods for measuring quantitative variables. *Com Bio and Med* 1989; 19:61-70.
31. Tammemagi MC, Frank JW, LeBlanc M, Artsob H, Streiner DL. Methodological issues in assessing reproducibility – A comparative study of various indices of reproducibility applied

## Test-retest reliability of psychophysical lift capacity, in patients with non-specific chronic low back pain and healthy subjects

- to repeat elisa serological tests for lyme disease. *Journal of Clin Epidemiology* 1995; 48:1123-1132.
32. Altman DG, editor. *Practical statistics for medical research*: Chapman and Hall, London, 1991.
  33. Evans WJ, Cayten CG, Green PA, Determining the generalizability of rating scales in clinical settings. *Med care* 1981; 14:1211-1220.
  34. Brox JJ, Storheim K, Holm I, Friis A, Reikeras O. Disability, pain, psychological factors and physical performance in healthy controls, patients with sub-acute and chronic low back pain: a case-control study. *J Rehabil Med* 2005; 37:95-99.



